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Contributions from members on matters of general interest are invited, and if suitable will be paid for at the rate of 10s. 6d. per page. Articles may take the form of descriptions of new plant or tools, interesting workshop methods and production problems, or shop organisation systems. All communications, other than those relating to advertisements, should be addressed to the Hon. Editor, Mr. E. D. Ball, 20, Lushington Road, Harlesden, N.W.10.

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EDITORIAL.

THIS is essentially an age of specialisation, since it is next to impossible nowadays to become proficient in more than one branch of engineering. In fact, specialisation has been carried so far by many engineers that they deal only with one phase of a particular branch of the profession.

This is equally true of the production engineer, in spite of the fact that the commercial men at the head of an organisation expect him to have a wide and intimate knowledge of every phase of the subject, from the pattern shop to the erecting department. Life is too short for anyone but a superman to acquire an intimate acquaintance with all the details connected with the numerous phases of work which come within the scope of our Institution.

This will be evident when it is realised that some of our members have for years devoted the whole of their time to a study of grinding practice alone, whilst others again specialise on such matters as die-casting, hot stamping, or press tool work. Others again are interested almost to the exclusion of everything else in foundry practice or drop forging, or in a specialised branch of machine shop practice, such as gear cutting, or the production of highly accurate screw threads or gauges. In addition, there are the many and varied problems of organisation, planning, progress stores, etc.

Engineers as a body are not slow to realise all this, but they omit to draw the obvious inference. They know well enough the

futility of attempting to cover the whole field of any one branch of engineering, yet as a class they are frequently very much averse to a general pooling of ideas and interchange of views on vital matters.

It is amusing to the spectator to see the jealousy with which so-called trade secrets are guarded by firms in competition with one another, but the matter has a more serious side. It is not in this way that progress is made to enable us to compete in world markets. What is required is a broader outlook and a much more open policy which recognises that from the free interchange of ideas nothing but all round benefit can result.

It is precisely in this matter that the Institution as a body, and this journal as the organ of the Institution, can perform the greatest service, not only to our own membership, but to the community as a whole. We would ask those members who are often up against it in the way of a difficult production problem whether it has ever occurred to them that some other member may have encountered the same difficulty and successfully overcome it? Further, does the man who successfully overcomes an obstacle realise that other people may be interested in his method of surmounting it? Usually, owing to the insular outlook which is habitual with many engineers, and with British engineers particularly, one is apt to overlook such facts. The result in the aggregate can only be an enormous waste of effort in solving the same problems over and over again.

To those who may be inclined to overlook this, we would point out the immense possibilities of co-operation amongst the members of the Institution. This can be achieved in a measure by queries raised during the discussion at general meetings. Another method which is open to members is to communicate particulars of difficult problems for publication in the journal, so that any who are able to do so will have the opportunity of suggesting solutions of the problems.

Whether it is possible to embody such a useful feature in the journal depends solely on members themselves, and we shall be pleased to receive their views on the matter. Members are also urged to make full use of the Correspondence columns for the discussion of matters of general interest, or for airing their views on the papers which are given from time to time, should they be unable to attend the meetings and take part in the discussion.

JIG AND SPECIAL PURPOSE MACHINE DESIGN.

As Applied to British Automobile Production.

By Mr. E. W. Hancock, of Messrs. Vauxhall Motors, Ltd., Luton.

AS the subject of jig and special machine design is of such a vast character, it would be impossible to treat it fully in one paper, but it is the author's intention to touch upon what are, in his opinion, the main fundamental principles which ultimately govern design. These fundamentals have been divided by the author into two classes : (*a*) the primary, (*b*) the secondary.

The primary principles are taken to be those which govern the jig design before the drawing-board is reached, the secondary fundamentals being those which are applied in the actual design of handy and efficient jigs.

The points which are dealt with appertain chiefly to the methods of production made necessary by conditions which exist in England to-day. Although the science of production is applicable to all things, the problems of production of the average quality car are different from those encountered in the case of low-priced, quantity-produced cars ; both these types, however, have a well-defined market.

Taking a design from the point where it has been accepted as in agreement with the policy of a company, and all experimental work has been done, then the main questions which present themselves to the jig designer are as follows :—

Primary Fundamentals.

1. Review of designs which are to be produced.
2. Permissible expenditure.
3. Quick introduction of new designs and alterations.
4. Machines available.
5. Number of pieces per week.
6. Accuracy and intricacy of component design.
7. Planning.

Review of Designs.

On quality cars the car designer should be left as free as possible so that the public may receive the full benefit of research

and design, but it is of the greatest importance that before the design is passed for production, full consideration be given by the main drawing office to requests made by the production department for modifications. There are many ways in which costs can be reduced by minor alterations in design, which in no way affect the ultimate functioning of the various parts.

The adjustments of clearances, the fixing of sensible limits for assembly, the modification of stampings and castings for holding purposes on first operations, die sinks or spotting bosses, etc., for jig location, are a few of the points that demand consideration at this stage.

Giving reasonable clearances for assembling affects the cost of production and design of jigs considerably. One often sees a clearance between one unmachined component and another of only 0·062in. or 0·125in., and in consequence great trouble has to be taken in jig location in order to maintain these very fine clearances without fouling, whereas, if a greater clearance were given, a simpler form of jig might be adopted and still avoid hand work in assembly due to accumulated errors.

There are many further points which these two departments can settle with the object of reducing costs of both production and jig. The author feels that too great a stress cannot be put upon the necessity of hearty co-operation between the main drawing office and the production department, as the results of such co-operation are far-reaching and have a considerable bearing on jig design.

Permissible Expenditure.

The financial allowances of a company to the production department have a very direct influence on jig design, and since it is a jig designer's function to expend this money to the best advantage, it is necessary to adjust the design of jigs to suit the allowance.

One often hears the well-worn expression, "it will pay you in the long run, even if you make a considerable outlay." Though it is admitted that a considerable outlay for jigs may be repaid in a few years, one has to bear in mind that enormous outlays are not very frequent in this country, especially when dealing with such a temperamental market as that for quality cars, where the public expect, and quite rightly so, some new and advanced feature every so often. One has to cater for as short a period as six months for the cost of jigs to be returned, especially in the case of a completely new design, as one must "feel the pulse" of the public before entering on a considerable outlay. It is interesting to note that the most prosperous quality motor car companies of this country to-day are those that have gradually felt their way forward. Therefore, the design of jigs has to be adjusted

to suit this particular policy, and the greatest number of simple but useful jigs has to be produced for a given small amount.

On the other hand, if the policy of a company be to lay down a design, the backbone of which is to last many years and the quantities are to be great, then with a large financial outlay the jig designer conceives his designs from a different aspect altogether, and, providing a sufficient amount of time is allowed, designs of

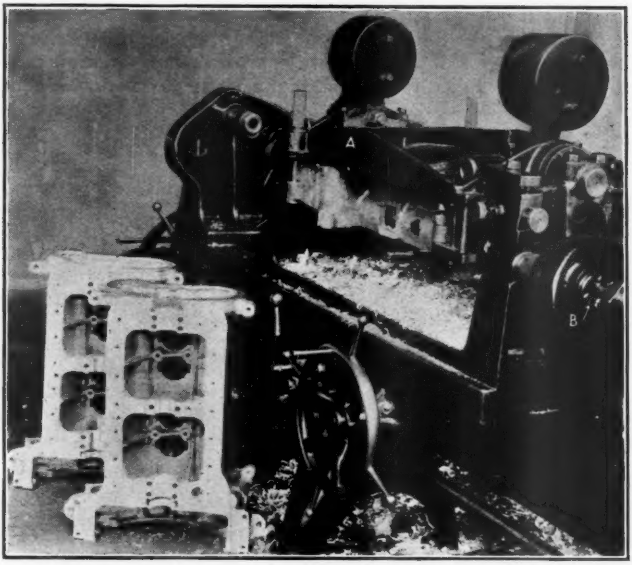

Fig. 1.—A crankcase boring machine.

jigs and special machines of a highly ingenious and efficient order are necessary.

Quick Introduction of New Designs and Alterations.

A problem which is often put before the production engineer is: How soon can a new design be produced in reasonable quantities and at a reasonable price?

It will be understood that there are many occasions when it is absolutely necessary that a new design or new piece of design be placed upon the market at the earliest possible moment, even though the quantity per week and the profits be lower than what are ultimately expected. It is frequently necessary to catch the

eye of the public at the right time, so that eventually when production is in full swing the pioneer company has prior claim on the market.

In dealing with production from this aspect the problem of the jig designer is to get as many jigs made as he can in the shortest possible time. The design of these particular jigs is not very difficult, as jigs of the very simplest character are necessary, since it is the number that chiefly affects time reduction.

If, as an example, a motor car is the particular mechanism to be produced under these conditions, then it is assumed that in the first stages of production there are approximately 105 components to be jigged, with an average of, say, 5 jigs per component; thus, roughly, 525 jigs are necessary to put this motor car on anything like a production basis. Comparing the machining time taken by using a simple jig, with the machining time taken without any jigs at all, it may be safely assumed that a saving of 50 per cent. may be made by the use of simple jigs.

If a further 25 per cent. of time saving is required, *i.e.*, a total of 75 per cent. of the time taken in machining without jigs, then the design of jigs will become more involved. Thus the time taken in design, the cost per jig, and the time taken to manufacture jigs will become greater, a reasonable figure for this increase being approximately three times as much. Then, if there are 525 jigs for 105 components to be produced, and these are of the simple order, they will be designed and made in the same time that it takes to make only 175 jigs of the more involved type for 35 components.

If the total time for producing these 105 components is approximately 50 hours, then the time saved by using 525 jigs with 50 per cent. time-saving efficiency will be 25 hours, and the time saved by using 175 jigs with 75 per cent. time-saving efficiency will be approximately 13 hours. Therefore, if there are 105 components to cover, then it is better to save 50 per cent. of the whole machining time taken in producing these 105 components without jigs, than to save 75 per cent. of 35 of these component times, and allow the remaining 70 components to be produced by the "hand and eye" method.

Hence a jig designer must at times restrain his natural desire to display expensive ingenuity in his designs, and put in hand a more elementary, but more numerous collection of jigs, until such time as the policy changes, output goes up, and he is given that which a jig designer most desires, *i.e.*, time and money.

Machines Available.

Jig designs are again governed by the number and type of machines available. Often, in order to balance up a machine

shop so that the greatest number of machine hours are available, it is necessary to put work on to machines which are not ideal for the job, and it is essential that the design of the jig be so arranged as to compensate as far as possible for this. Thus a boring and facing operation which would be best carried out on a combination lathe, may be allocated to a boring machine, in which case jig pilots should be arranged in such a way as to give accuracy and finish. Again, a drilling machine may be used for a job which would best be done on a horizontal machine.

To make a complete change in the machine tool programme for every new design put before the production department would

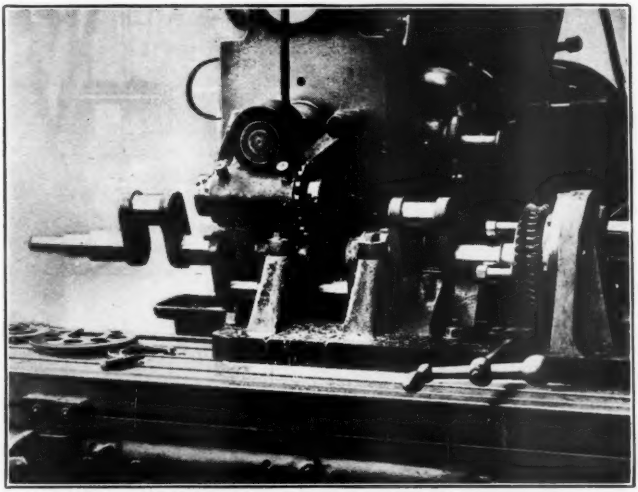

Fig. 2.—A milling jig for Lanchester balance gear wheel slot.

mean not only considerable expense but in many cases serious delay, especially when a product is of such a character that designs are frequently being changed and where quick introduction is necessary.

Again, if a certain machine or machines are in a bad condition, and the financial allowance is not sufficient to purchase new machines or even to cover constant overhauls, the jigs must be designed so that they are of a more complete character. In the case of worn drilling machine spindle bearings, if accuracy is required, then top and bottom pilots on the jig are necessary; also in the case of a combination lathe with the turret out of line,

probably caused by excessive local wear on the bed, then a forward and rear pilot should be used with a universal joint on the boring bar. This also applies to worn boring machine spindle bearings or table, where only a degree of skill peculiar to this particular machine makes it possible to line up with the job, unless the jig be provided with liberal back and front pilots, with universal joints on the boring bars.

It is very important that a jig designer should fully understand the machines for which his jigs are designed. This implies more than a knowledge of the machines acquired from the operator's handbook. He should become as closely acquainted as possible with the peculiarities of each machine, so that he may counteract by careful jig design some of the defects in the machine tools for which they are intended.

In the case of special machines, it is advisable to make these as adaptable as possible within their limited range. For instance, in designing a crank case boring machine, it is possible to arrange it so that it will deal with any normal crank case of similar type. Thus when a modified design is presented, adjustments of heads may be made, and a new jig plate supplied.

The machine shown in fig. 1 is of this class, as by changing the jig plate A for another type, and adjusting the heads B to suit the new jig. plate, it is easily adapted to another type of crank case. Moreover, even if the two types are running concurrently, this is still feasible, as the change over takes only twenty minutes, whilst the accuracy is entirely controlled by the jig plates.

Number of Pieces per Week.

The question of weekly output has to be considered when designing fixtures. For instance, in the production of a motor car there are some components of which there is only one per car, and again other parts of which four, six, or eight per car are required. It is then often necessary to give more attention to time-saving on the more numerous components than on the single ones. It is permissible to spend more money on an ingenious jig for the multiple components, so that a correct balancing of times may be obtained. In such cases handling times should be cut down as much as possible, and quick-acting levers and locking devices should be introduced.

If all the jigs were of the same efficiency per piece, then the load on those for the multiple components would be in excess of other jig loads on single components. These jigs would then become the weak link in the chain of production. Viewed from another aspect, if all jigs were of the same efficiency per piece, and the jigs for the multiple components were quite equal to dealing with the total number per week, then unnecessary money

has been expended on the jigs for the single components, as their efficiency is above the output requirements.

Again, apart from relative numbers, total numbers according to policy must be considered, as this has a very direct bearing upon jig design. A jig for producing ten components per week is of a different order from one for producing one hundred of the same components per week in the same shop. Hence the question of how many pieces per week, both with regard to the total and relatively, must constantly be before the jig designer, so that he

Fig. 3.—Lining fixture for connecting rods

not only caters for the total output, but balances his jig efficiency so that the most economic return is made for a certain expenditure.

It is very necessary that the policy of a company should be as consistent as possible, otherwise if changes are continually being made with output, the jig designers vary their ideas. If 50 per cent. of the jigs designed are for an output of ten per week and the other 50 per cent. are designed for twenty per week, a lack of balance in efficiency will result in the shop. Further, if jigs have been designed, say, for ten per week, and an increase of 100 per cent. in output is made, it is highly probable that many links in

the chain of production will break down owing to the overload on certain jigs which are out of proportion and unsuitable for the new output.

It is therefore advisable, although slightly more costly, to design a jig with a safety margin of output, over and above that dictated by the prevailing policy at the time. Then in the event of an extra load no immediate breaks in the chain are made, and sufficient time is allowed for strengthening the weak points.

Sometimes the loading of a particular type of universal machine is so great (not only because of relatively larger numbers of components, but because a certain operation is difficult, and in consequence lengthy) that it is necessary to design a special machine to relieve the universal tools. This is especially the case when a universal machine is employed for a difficult or unusual operation.

Accuracy and Intricacy of Component Design.

There is no doubt that the problems of production of the present day are vastly more difficult yet more interesting than they were twelve years ago.

The trend of modern motor car design is undoubtedly to make everything as "tight" and "lean" as possible, in order to reduce weight and to give a neat appearance. In these days of high efficiency the last 0·0005in. means a great deal, the accuracy of fits, the correctness of weight distribution, the demand for dynamic balance on rotating components, the use of higher grade materials to reduce cross sections, the more adventurous designs encouraged by the efficiency of production methods, are some of the many factors which have advanced the science of production. In fact, there is very little that even the most theoretical designers can put forward which the production department, given sufficient time and money, cannot produce on an economic basis.

Thus another important matter for the jig designer to consider before he commences his designs is what degree of accuracy is necessary to make a component an efficient unit of a complete mechanism. Does the component warrant an elaborate jig, apart from quantities per week, or will a simple jig produce the required result?

A knowledge of the ultimate function of the component by the jig designer is very useful in deciding this question.

With modern design the correct selection of datum faces often determines the ultimate efficiency of the jigs. Very careful study has to be given to this point, and great foresight on the part of the jig designer, in visualising the subsequent operations, leads him to choose the most desirable first datum. There is no doubt that if considerable thought is given to the first and second operations to ensure holding without distortion in order to produce

flat faces, locating in such a manner that the following operations are taken care of, etc., much subsequent anxiety is saved. The following operations may be carried through, proper jigs being provided, by semi or unskilled labour, with tolerable certainty that the ultimate job will be within the limits required.

On the other hand, it is almost certain that inaccuracies in the early operations will follow through with the component until the end, and in many cases not even grinding will eliminate errors which are passed down from the beginning. This principle of starting well has many parallels in life, and the importance of

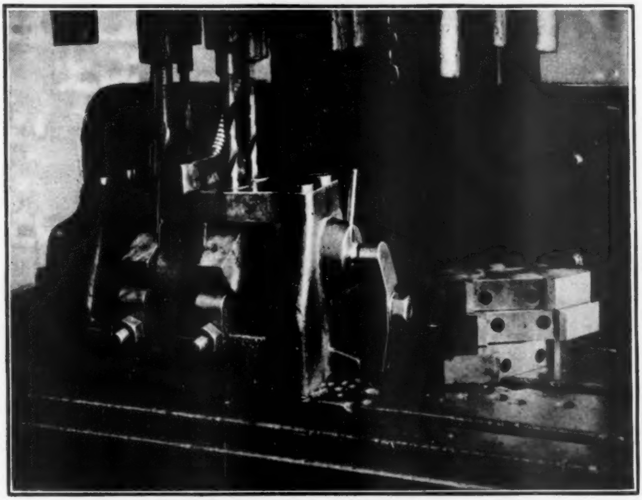

Fig. 4.—Drilling jig for crankshaft balance weight.

commencing a series of operations correctly cannot be too greatly stressed. The degree of accuracy of components governs the design and sequence of jigs very considerably, and it is important that the designer should have in mind the last jig of a sequence when he is designing the first.

It is the author's opinion that it is desirable, if possible, to give one draughtsman a complete sequence of jigs. Although in a sequence there may be some jigs which are simple, and probably below the status of a particular draughtsman, it is better to let one man produce the complete series, thereby co-relating each and every step.

In the case of intricate designs it is again often necessary for

the jig designer to resort to devices of an ingenious nature, regardless of the output per week, or cost per jig, in order to be able to produce components at all. As a result of modern tendencies in car design, the average cost per jig is increasing. Where at one time it was good enough, from an efficiency point of view, to machine by methods which called for little accuracy, it is now often in the power of the machine shop to make or mar the efficiency which the designer set out to obtain, by deviating only very slightly from the designer's theoretical desires.

Planning.

The planning of a component embraces all the six abovementioned factors, and for planning a complete knowledge of these factors is absolutely necessary. It is most essential to know, on the one hand, the full policy of the company, and, on the other hand, the possibilities of the shops in which the policy is to be carried out. Planning directly determines the sequence of jigs, and must therefore be executed with the greatest care and forethought, interpreting the general aims of the policy into manufacturing possibilities.

Jigs depend largely on the planning for their degree of efficiency and their cost. Further, the balancing of jig efficiency, having regard to all things, rests mainly with the planning, and rough estimates of jig costs and efficiency must be considered by the designer before a certain method of planning is passed, so that a consistency with policy is achieved. Often a jig draughtsman is tempted to use an excessively costly idea which is out of proportion to the main sequence, and in many cases this is quite understandable. The chief designer must, however, keep within his limited range, according to policy, otherwise he may forfeit general efficiency for one or two individually efficient operations. In other words, he may violate a primary principle for the sake of a secondary consideration.

There are always two or three alternative methods of production, all of which have their respective virtues, but there is usually only one method which is best suited to a particular policy, shop, or class of labour available. It is only a close knowledge of these facts that makes it possible to achieve the correct degree of efficiency from money expended on jigs, and it is only this that makes a jig designer valuable to the particular company which commands his services.

Secondary Fundamentals.

Having dealt with the main fundamental principles, and with full knowledge of the limits within which the designs must be kept, the jig designer should prepare to lay down on paper the most ingenious and efficient jigs according to those "limits."

It is clear that different forms of components present many different problems, but below the surface of these diverse problems it is possible to trace a reasonable consistency in the principles employed in their solution. It is proposed to give a brief outline of what are considered to be the chief of these principles according to the particular machine groups on which jigs are mostly used.

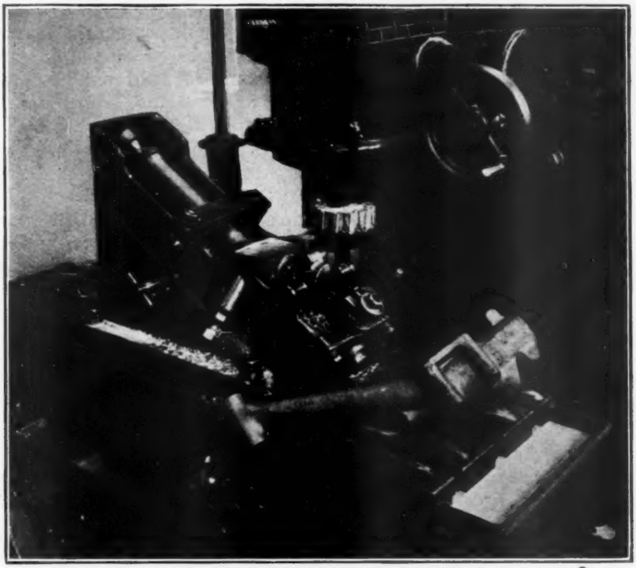

Fig. 5.—Milling jig for front axle arms.

Capstans and Full Combination Lathes.

Usually capstan lathe jigs have to deal with the component after a first datum face has been machined, but a capstan being of a universal nature, and the class of labour being reasonably skilled, it is possible to machine a first datum face with the use of an adjustable type of jig.

It is not always wise to provide fixed points on first operation capstan jigs, especially for castings, but given one or two spotting points or faces, it is possible very quickly to adjust a jig and produce a component within required limits, having regard to subsequent operations.

This type of jig can cover a reasonable number of first operations, and provides, with comparatively small outlay, a means of economical production, taking into consideration many of the errors which are bound to exist on stampings and castings. This does not necessarily mean that adjustments have to be made for every component, but that it is left for the operator to use his skill and judgment according to the variations which exist. It is sometimes necessary to have lines marked in two planes on the component for use in setting up.

Second or third operation jigs, dealing with components which have a datum face already machined, should be of simple construction and robust, so that a definite and firm hold may be taken on the component.

Wherever possible a back pilot should be provided integral with the jig, and it is the author's experience that a well-hardened mild steel pilot bush, used in conjunction with a well-hardened mild steel bar, gives the best service for all normal work.

There are certain materials, such as aluminium and its alloys, which sometimes give trouble when using steel pilot bushes. In these cases phosphor-bronze can be used, but a phosphor-bronze bush has not the same life when accuracy is taken into account as well-hardened mild steel, and a more rigid watch has to be kept on jigs which have phosphor-bronze bushes. In cases where extreme accuracy is required, a front as well as a back pilot should be provided, and the boring bar allowed to float in a universal holder.

All rotating jigs should be designed with components to be in static and dynamic balance, more care being taken with jigs dealing with material which has a high cutting speed. Gauging faces and tool-setting blocks are a useful addition to capstan jigs, and when carefully used save time in setting up, and give consistent results.

Sometimes a large component calls for a large overhanging jig, but designers should not be afraid of a large capstan jig, as when used in conjunction with an adequately designed steady, good results may be achieved. The average high-class capstan has a strong and well-supported work spindle, and, providing the jig is well balanced, its design may be quite robust. Weight can be reduced if the casting is properly webbed and tied, in accordance with the stresses which are likely to be put upon it, but it is not advisable to run the risk of a breakage for the sake of a little extra metal.

In connection with capstan jigs which are employed on machines of the screwed nose type, the use of standard face plates is advised, as, first, the jig cost is reduced, and, secondly, providing the face plate spigots are of the same size, interchangeability of jigs and machines is allowed for.

Automatic Lathes.

The type of work for automatic jigs is that which has had a datum face machined, as definite holding of the work is necessary, in addition to which the class of labour on autos. will not permit of much work setting. Work should be very rigidly held, and a definite driving peg or block should be provided, no reliance being placed upon the friction of the clamps. Owing to the fact that one operator is probably minding two or three machines, and since the tools are definitely controlled by cams, no possible chance should be given for the work to move in the jig. Balance is, of course, necessary for automatic jigs as for capstan jigs.

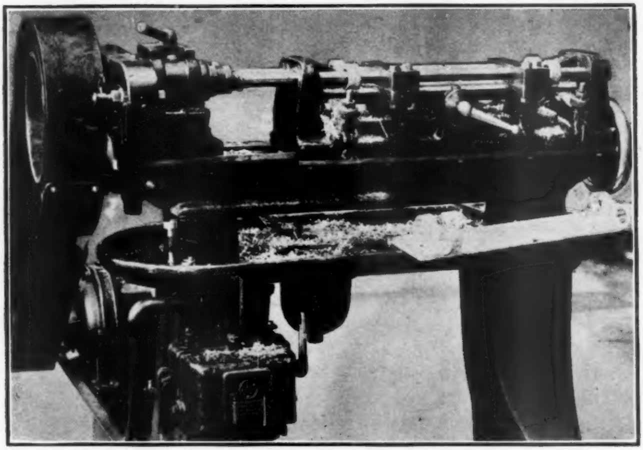

Fig. 6.—A line boring machine for dynamo brackets.

Milling Machines.

The action of a milling cutter calls for extreme rigidity in clamping the component, and jigs of the most robust nature are necessary. Milling jigs should be so constructed and bolted down that no " panting " between the jig and the machine table can take place, otherwise a good finish is impossible. One frequently sees a fairly rigid jig, with the holding down bolts at the extreme ends, leaving the centre of jig free to move or " pant "; this is very dangerous, and arrangements for central bolting should be made.

The point of cutting should be brought as low down to the machine table as possible, giving stiffness to the system and so

minimising vibration. Designers should not be afraid of putting plenty of material in milling jigs, as a breakage on a milling machine is usually serious. Operators are trained, and quite rightly so, to clamp down components as hard as they can. Hence if plenty of material is put into the jigs and clamping studs are screwed at least $1\frac{1}{2}$ to 2 diameters into the casting, and clamps have a large factor of safety, then the operator can tighten down to the limit without causing any breakage. There is otherwise a chance of breakage from excessive tightening of clamp nuts as well as from the action of the cutter. The cutter should always act against the jig casting and not against the clamp.

The question of adequate swarf clearance is important, and if the jig is boxed in, then proper swarf-removing gaps should be provided. Steel milling calls for plenty of "suds," and should the jig be large and possibly extending over the table width, then proper "suds" gutters should be provided round the jig to collect the liquid.

Cutter setting pieces and gauge faces are very useful on milling jigs. These setting pieces should be clear of the cutters by a known distance, say, 0·010in., and the amount should be marked on the setting piece thus: "Use 0·010in. feeler." Should the setting piece be damaged through contact with the cutter, the faces may be ground back to clear away the damaged portion, and the jig re-stamped with the new feeler distance according to the amount which has been removed.

Many first datum faces are created on the milling machine, and the adjustable type of jig can be used to great advantage on awkward castings, setting lines being marked on the work. Fixed, first operation jigs are satisfactory on milling machines, but in one plane there should be only three fixed points, and in the other plane two in one direction and one in a direction at right angles. Any remaining supporting points which might be necessary should be of the spring plunger type. This method of holding without distortion is applicable to machined surfaces as well, if accurate results are required. For holding very flimsy aluminium components, the use of properly constructed spring plungers make it possible to turn out accurate work.

A satisfactory spring plunger is one which has a flat ground at an angle of about 10 deg. on the side, a separate cast-steel pad also ground at 10 deg. being fitted into a hole at right angles to the plunger. The pad is located radially by a groove and pin and forced on to the plunger by a screw, whilst under the plunger a spring is used, the free length of which is about a third more than the length required when the whole is assembled.

If the method of location of the piece be from two reamed holes, and the component be of reasonable size, it is advisable to use loose locating pegs, and to insert them after the component is

placed square on locating face. If the two locating pegs are fixed, and the component is of large size, difficulty is experienced in loading, for to keep a large component square whilst lowering

Fig. 7.—Special equipment for cylinder boring.

it on to pegs is almost impossible. Binding on the pegs is the inevitable result and unloading is made difficult.

The use of a lead hammer is not unknown in these cases, but

it usually results in damage to locating holes, which may be required for a subsequent operation as well as giving rise to possible distortion and inaccuracies in the component.

Boring Machines.

Boring machine jigs where possible should be of the independent type, having adequate pilots back and front, and a universal joint on the boring bar. If this method be adopted, then the accuracy is entirely dependent on the jig, and the machine is only used as a driving medium. Such jigs should be robust and rigid, and, providing the component is held without distortion, and that the above method of bar piloting is adopted, very accurate results can be achieved. Well hardened mild steel pilot bushes give fairly long accurate life.

Great attention should be paid to swarf clearance, for, as with milling jigs, the swarf is " dead," and becomes a serious nuisance if not properly catered for. The author feels that, owing to the demand for greater accuracy by modern car designers, and owing to many of the complex shapes of small flimsy castings, there is a demand in the machine shop for a small high-production horizontal boring machine.

Drilling Machines.

Sight and target locations can be used to advantage on inexpensive drilling jigs. Raised faces on the jig machined in relation to the bushes, and corresponding to component faces to be drilled, give very reasonable results. Sighting lines and sighting holes used in conjunction with a line marked on the component make it possible to split errors on castings without going to the expense of compensating locating devices.

If the work be reasonably simple, then fixed locating vees, or points, may be satisfactorily used on the outside of castings and stampings. Swarf needs serious consideration on drilling machines, and on this account the drill slip bush should be carried as close to the component as possible, so that the swarf is carried up the flutes of the drill, instead of packing between the component and bush.

Although the hole being drilled has a reaming operation to follow, it is important that the drilling be as accurate as possible, otherwise difficulty will be experienced in getting a clean hole from the reaming. Lack of attention to swarf and " suds " may also give rise to considerable trouble in reaming. For long hole drilling it is advisable to have a turn-over jig and drill from both sides, afterwards reaming right through. The reamer should be piloted top and bottom if possible, and held in a floating socket. It is not wise to attempt to drill a long hole right through from

one side, especially if the component has little metal round the outside, as run of the drill invariably takes place.

It is not advisable to employ the component as part of the jig, as any inaccuracies in the work will have an influence on the drilling. If possible, clamp the face to be drilled up to the jig in either a box jig or a plate jig supported on legs; this method ensures bushings being in alignment with the drill spindle. Small box jigs for fixed spindle machines should be as handy as possible, having hand levers and hand-locking devices, as to use a loose spanner on this type of jig is awkward.

On the larger jigs used on radial drilling machines, the jig is bolted to the table and clamp tightening by means of a loose spanner is convenient. Jigs for multi-spindle machines should be of the loose box type, but with pilots locating the jig plate in relation to the drill spindles.

Grinding Machines.

Grinding jigs should be kept very clean on locating faces, and for very accurate work, instead of using a plain bore and face, in cast iron or steel, four hardened and ground steel plates locating on diameter and face, with clamps in corresponding positions, should be utilised. If this method be adopted, then just the four hardened pads need cleaning before loading a fresh component, and for replacement when the bore wears four more pads may be fitted and dowelled, and ground up to dead size again. Leather-faced clamps are useful for preventing damage to a finished face.

Owing to the accuracy required, the use of unspigoted jigs on the face plates is advised, as to endeavour to remount a jig on a standard face plate within 0·0005in. locating off a spigot is a difficult task. With the unspigoted jig this can be mounted on the face plate and set true with an indicator on the locating bung or bore, and then locked back to the face plate by bolts. Properly bolted together, the jig will not move on the face plate, and dead accuracy is ensured.

Jig construction should be as light as possible, and accurate balancing is essential. These two features are necessary on account of the very small and light work heads and spindles of the standard grinding machines of to-day, and on account of the degree of accuracy which is aimed at on grinding machines. A rough check on the permissible weight is to keep the combined weight of the jig and component within that of the standard chuck for the machine plus the weight of a reasonably heavy component. It is not always possible to design a lightweight fixture, owing to the nature of the component to be ground, and in these cases outside adjustable steadies may be used to advantage.

There has been a considerable increase in the number and variety of grinding operations in the past ten years, and more and more

work, needing fixtures, is being placed on the grinding section. This is giving rise to an increasing demand for machines with work heads of very much more liberal proportions.

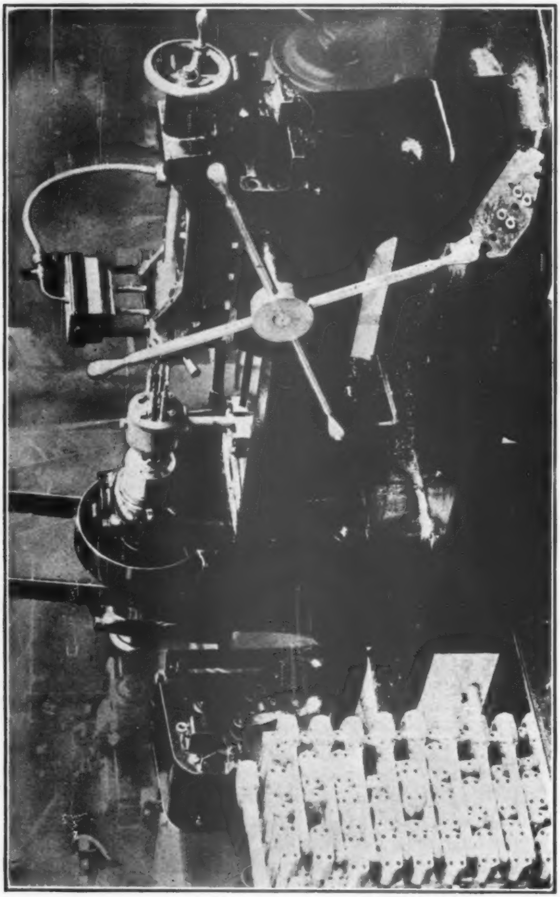

Fig. 8.—Drilling connecting rod bolt holes.

General Observations.

A few examples of actual jigs and special tools will illustrate the principles mentioned in the paper. Reference has already

been made to fig. 1, as showing the method of making a fixture self-contained as far as accuracy is concerned.

An unusual operation is shown in fig. 2, which illustrates the special head and fixture for milling a slot 0·375in. wide round the web of a crankshaft to take the Lanchester balance wheel. Fig. 3 illustrates an assembly fixture for ensuring that correct alignment is obtained between the pistons, conn. rods, and crankshaft pins. For this purpose the shaft is mounted in bearings similar to those in the crank case, and is located endwise. A vice at the rear of the fixture is used for correcting the rods.

A jig for drilling the bolt holes in the crankshaft balance weights is illustrated in fig. 4. Two opposed wedges force the components upwards, so that the drill bush is in contact with the job, and the swarf is carried up the flutes of the drill. Two clamps and push rods secure the components laterally.

An awkwardly shaped component is that illustrated in fig. 5, which shows the jig for milling the seating on the front axle arm. This seating is the basis of subsequent locations for drilling and boring the component.

Figs. 6 and 7 show examples of boring machines in which the accuracy is controlled by the fixture instead of relying upon the centres of the machine spindles. To allow for any slight misalignment between the boring bars and the driving spindles, a slight amount of float is given in the coupling.

In fig. 8 a special attachment for drilling connecting rod bolt holes is shown. This makes use of a compact four-spindle head driven from the machine spindle and prevented from rotating by a pillar engaging the bed of the machine.

A very large proportion of jig design, apart from policy, is governed by the practical aspect, as extreme caution and a fair degree of certainty of the jig functioning must accompany the design, for little time is allowed for experimental work, and a jig failure is invariably disastrous to output. Few risks must be taken by the designer. Any novel features which may be introduced must have a sound backing; very venturous designs are prone to disaster, and if the principles are wrong the jig is inevitably a failure. Good, sound, time-saving jigs have very few "frills," and, although a higher factor of safety may cause an iron casting to look somewhat cumbersome, it is better to see a cumbersome but whole jig rather than a pretty jig in halves.

A question of importance is the quick introduction of new jigs into production. In connection with this point, the same principle of adequate clearance is applicable to jigs as to motor cars, or any other mechanical device, and jig detail draughtsmen are advised to give this question considerable attention. Nothing is more annoying than to have a new jig which is correct in all its fundamentals, accurately made, price good, and then to have to set it

up again to mill clearances on the casting, or to give more clearance on moving parts so as to allow the piece to enter the jig, or to allow the moving parts to reach the work. The minimum clearance anywhere on a jig, where possible, should be 0·375in. Even this amount is sometimes taken up by an accumulation of errors, each one in itself not being large enough to condemn.

All these nibblings at castings, etc., on finished jigs are an additional cost to the jig, and take time to carry out, apart from destroying the appearance of the jig. Most of this trouble could be saved at the drawing-board stage. A motor car designer has a certain excuse for trying to cut his clearance fine, in so far as weight reduction and neatness are concerned, but a jig designer need not bother with fine clearances. Individual errors on castings may be minimised by the detail draughtsman in his method of dimensioning, as he can indicate where the clearances are needed.

It is important that a design be kept in the " molten " condition as long as is reasonably possible on the board before making a final decision, as a modification at this stage is easy.

Care should be taken so that the jig allows for the use of adequate standard tools, but it is not advisable to forfeit the efficiency of the jig for the sake of using standard tools. Extreme care should be taken by the designer to accommodate for special tool layouts, and although the jig designer must not allow the efficiency of the jig to be affected, he should give every consideration to the tools, so that the cutting has the best possible chance, and the manipulation of the tools is as handy as possible.

An important feature, upon which a fair measure of success depends, is the necessity of keeping the draughtsmen familiar with as much of the main policy as possible, and familiar with the shop in which the jigs are to be used. Hence free access to the shop should be given to draughtsmen, subject to the necessary supervision, so that they may commence designing with a detailed knowledge of the likely pitfalls which await their jigs.

This point is of especial importance when training junior draughtsmen, as the sooner they are able to appreciate the importance of working according to certain policies and limitations, so they are able to keep a fertile mind, and to adapt their ideas to the policy of the company for which they are working. Sympathetic knowledge of a company's policy is of vital importance to a jig designer, and if this is coupled to ingenuity and common sense, a fair measure of success in jig design is guaranteed.

In conclusion, the author expresses gratitude to Messrs. Vauxhall Motors, Ltd., for their generous courtesy in lending the lantern slides, etc. ; also for the liberal facilities for gaining experience which have been extended to the author, by virtue of which he has been able to prepare this paper.

COUNCIL COMMUNICATIONS.

IT was decided at the Council Meeting held on November 28th to publish, under the above heading, brief items of news relating to the business transacted by the Council. As is probably well known, the Council meets under ordinary circumstances once a quarter, and the next meeting is due to take place on February 27th.

Arising out of a resolution passed by the Coventry Branch, it was thought that the Council could better serve the interests of members by inviting suggestions from them regarding any matters which might profitably be considered by the general Council. With this object in view the Agenda for subsequent Council Meetings will be published in the issue of the Journal prior to the date on which the meeting is to be held, and members will be invited to send in suggestions to the Secretary so as to reach him seven days before the meeting.

Although members elected at the meeting on November 28th were not numerous, owing to the fact that increasing discrimination is being exercised by the Council in this matter, we have the pleasure of adding the following names to the Institution Register :—

Members.—William Walker Bode and Alfred John Brain, of Messrs. Burton Griffiths & Co., Ltd., 64-70, Vauxhall Bridge Road, Westminster, S.W.1.

Associate Members.—Claud Henrick Benbow, 21, Uxbridge Avenue, Coventry; Raymond H. Best, The Accounting and Tabulating Co., Ltd., Croydon; Thomas Francis Tribe, Messrs. Gillett & Stephens, Atlas Works, Bookham, Surrey.

Graduates.—Donald McQuillen, S.A. Fabrica Argentina de Alpargatas Calle Patricios 1053, Buenos Aires, South America; Frederick John Cordwell, Wright, Bindley & Gell, Ltd., Percy Road, Freet, Birmingham; James Frederick Sturdy, Standard Motor Co., Ltd., Coventry.

Messrs. Burton Griffiths and Co., Ltd., were also elected an Affiliate Firm of the Institution, Mr. Bode being the Affiliate nominated by them.

Another matter considered at the last meeting of the Council was the question of arrears of subscriptions. The Secretary was instructed to prepare a list of members showing the amount by which each was in arrears, so that this might be considered by the Sub-Committee, who would determine what action should be taken and report to the Council accordingly. Members who may be in arrears are asked to give this matter their attention, and those who may be prevented by hardship, or causes outside their own control, from settling arrears of subscriptions, are advised in their own interest to communicate such facts to the Secretary instead of letting the matter stand over.

ANNUAL GENERAL MEETING AND DINNER (continued).

Reply to the Toast of "The President."

THE PRESIDENT, replying to the toast and expressing thanks for the nice things that had been said of him, said he realised that the task which lay before him was no easy one, and he could only hope to live up to the high standard of efficiency set by his predecessors. So far as the future of the Institution was concerned, he was perhaps fortunate in having an unbounded belief in the utility of the Institution.

There were one or two matters which were very dear to him to which he would like to refer. During his Address earlier in the evening he had referred at some length to the work that the production engineer does, and he now proposed to say a few words about production engineers themselves. The first matter was the status of the engineer to-day. During the war, when our armies were hampered by a terrible shortage of munitions and when we were being slowly overcome, to whose lot did it fall to bring about a change? It was not the lawyers, it was not the doctors, nor the accountants, bank managers, stockbrokers, nor the dentists, or any other so-called professional men. It was the prowess and skill of the engineer which provided the means whereby thousands upon thousands of people, totally unskilled, were able to work on the production of the many mechanical contrivances for war that were necessary. How was it that work which had hitherto been looked upon as only possible for the highly skilled artisan to do, was capable of being done by these unskilled people? It was simply the outcome of the application of the knowledge of the engineer, when the occasion arose, which enabled this to be done. That was the position during the war. But what of to-day? We could not shut our eyes to the fact that just as in 1915 we were fighting for our existence as a great nation on the battlefields, so to-day we were fighting for that same existence in the industrial markets of the world. He had already referred in his Address to the deliberate restriction of output practised by many workers in our factories to-day. Added to that were higher wages, higher establishment charges, and altogether an overburden of taxation. Such were the conditions prevailing in the engineering industry to-day; the engineering industry, which was one of the very greatest pillars of our national prosperity, and once again did it

fall to the lot of the engineer to provide a solution which would enable the large employers to meet those altogether disproportionate financial burdens. He maintained that in this work the engineer was surely but slowly succeeding.

What qualification was it which enabled the engineer to do this? It was not just a smattering of technical knowledge picked up here and there, not some hours of learning from text-books, not just a few years spent in the shops. No, the engineer of to-day had to pass through phases of learning identical with those of the other established professions. After he had served his apprenticeship, if he were fortunate, he would spend at least three years at a technical college or one of the universities. If, as so many were, he was less fortunate he had to attend night classes regularly throughout the period of his apprenticeship. From this stage he passed on to that of improver and then mechanic, and then, if he had proved his merit, and only then, he started to rise. It might be said that this was where he ceased to be a mechanic and where he started to be a very junior engineer From this point the way was clear, and he thanked God that in this profession a man could rise to any heights commensurate with his abilities. If a man became adept in the use of forceps, was he a dentist? or be he ever so skilful in the use of the knife, was he a surgeon? He might be a perfect marvel in the use of his tongue, but that did not make him a barrister, and he asked why in the name of all that was holy a man who could snap rivets on the sides of a ship or could turn a locomotive wheel in a lathe, should be entitled to call himself an engineer? It was possible to pick up a morning paper and read of what the engineers were doing, and as one read one found that the riveters wanted this, the boiler-makers wanted that, and the coppersmiths wanted something else, and the dear old man in the street went jogging merrily along in the old, old way, breathing anathema on the engineers because his pet shares had dropped three points or his coal would cost him more this winter, because you see he had somehow got mixed up in his mind between the miners and the boiler-makers, or coppersmiths, that is the engineers to him. He only knew what he had read about them all wanting a pound a week more or about four hours' work a day, or something or other, but he didn't quite know what, and he didn't much care. You may meet him at a social function and he thinks you are quite a decent sort of chap until some fiend whispers in his ear that you are an engineer, then down goes your stock ten points below par, and he may look at you sympathetically and wonder why you should want a pound a week more, or if you were " really " put to engineering because you weren't a bit of good for anything else in the wide world. He possibly throws sidelong glances at your pockets to see if you have a red flag sticking out, and there is one thing he is quite sure of, and that

is that at one time or another you must have lived at Coventry. That was the status of the engineer to the man in the street to-day. Forgotten was the work done in the Great War, unthought of, unappreciated, the work being done to-day, and simply because they were not a recognised profession. That and that alone was their weakness. Therefore, let the engineers get together and throw up their defences, let the gates into the profession, of the mechanics who want to rise and get on, be many and wide, but let them be well guarded. He did not wish them to run away with the idea that he was advocating a new trade union or a mutual benefit society. The point was that the employers themselves, many of whom were the foremost of our production engineers to-day, must come in with the engineers, and the engineers must see to it that these employers were gathered into their ranks. The time had arrived, in his opinion, when there should be a central body composed of men drawn both from the heads of our large engineering industries and from the principal of our engineering institutions in this country to get together and thoroughly investigate the whole matter, and draw up a proper definition of the term "engineer," defining those qualifications which it was necessary for a man to hold to enable him to claim the title.

Another matter which vitally affected the profession was the tuition of the young fellows who entered it with the idea of rising to positions of trust and responsibility. In a few—he was sorry to say only in a very few—of our large works this was excellently provided for, but in how many works was the apprentice looked upon as someone who did not matter? He, personally, considered it to be the bounden duty of all those in authority to interest themselves to the utmost in the tuition of these young fellows, so that when they came out of their time they were worthily equipped to uphold the profession. Just as the file and the hammer were the tools of the mechanic, so were the contents of the text-books and Engineering Pocket Books to be looked upon as the tools of the engineer; the learning derived from them was useless if it were not supplemented with the knowledge how to apply it in practice. It was for the elder man to see that the opportunity of obtaining that knowledge on the part of the young man is amply provided for. The engineering profession to-day was in want of more "big" men. There were many, but there were not enough. He had given this point a good deal of consideration, and had come to the conclusion that it was the "big" men themselves who were largely responsible for this. In these days of heavy expenses, and when possibly jobs were none too numerous, it was a lot to expect of a man that he should assert himself to his full capacity, but it was for those at the head of the profession to encourage the men to do that. To make a man

"big," it was necessary to treat him as "big." If a man was given a job he should be left to get on with it without let or hindrance, and he should be given all the help and encouragement that was possible. He should not be interfered with, and he should be trusted implicitly. Let him see that he was believed in, let him feel that he was not being doubted, and he would never have to be doubted. His subordinates should be left with him to deal with, and he should be made to feel instinctively that he was the only man to look to in connection with his particular work. If he did not swell under this treatment, then he had stopped growing, and it were better to change him before he began to shrink. In any organisation where such treatment was meted out to the staff, they were inevitably happy and content in their work, and a body of men pulling together in a team, without bickering, without personal jealousies, there was efficiency, and, last and greatest of all, there was loyalty. If the foundations were built big enough and strong enough, there was no limit to the magnificence and size of the edifice which could be built thereon.

There was one more point, and it concerned not only engineers but the whole nation. Mr. Scaife had referred to there being more than one reason for the present state of trade, but he did not agree with him. The state of trade to-day, bad as it is, could be rectified, and it was in our own hands, and the hands of our wives and families to do away entirely with unemployment in this country. It was an extraordinary thing to him that any man in this country should buy a single foreign article when he could purchase as good an article made in this country. Very often a person would rather buy a foreign article at 1s. 9d. than a similar British article at 2s. or 2s. 6d., but if people would only stop to think, they would realise that it is cheaper to buy the British article at the higher price because of its effect upon unemployment here. During the war there was a great flame of patriotism in this respect, but now we saw that flame of patriotism flickering and dying out. It was unpatriotic, in his opinion, for anybody to buy a foreign article if he could buy the same goods made at home. In this connection, he might mention the stamping machine used by the Post Office authorities for stamping our letters "Buy British Goods." It was pointed out to the Postmaster-General that these machines were of foreign make, and the reply was that it is the policy of the Post Office to buy their goods whenever possible at home, but that in this case the machines could not be purchased here, although the dies were British made. Another instance of this sort of thing was that of one of our greatest Cabinet Ministers who addressed a meeting in Greenwich on the subject of buying British goods, and, after having spoken eloquently upon the subject for a long time, he was seen to leave

the meeting and go away in a Packard car. He was not suggesting that it was the Packard cars that mattered in themselves, but it was the effect of this sort of thing throughout. For instance, some months ago his grocer sent him Japanese matches, but he went to the shop and told him, in front of a number of customers, that if he dared send Japanese matches again he would take all his custom away and see that all his friends did the same. That man had not stocked Japanese matches since. But £3,000,000 went out of the country every year in purchasing foreign matches, and many of the people who bought them could easily afford the little extra which British matches cost. It was different with the poorer man who had to count his pence, and he was sorry for him, but this was the type of man who generally was not unpatriotic. It was too often the people to whom the extra cost of the British goods made no difference who purchased foreign articles to the detriment of employment in this country. Just as it was with matches, so it was with millions of pounds' worth of foreign goods which came into this country every year which we manufactured just as well here; and if all those present would go away from that meeting determined not to buy any foreign article when a similar article made at home could be obtained, then there would be no need for Government help or anything. We should be able to cure unemployment ourselves.

EMPLOYMENT BUREAU.

Members are asked to do all in their power to make the Employment Bureau a useful feature by forwarding particulars of positions likely to be of interest to those who are seeking new situations.

MEMBER seeks position as Superintendent, Works Manager, or Representative. Up-to-date experience with motor and railway engineering firms in responsible positions. Excellent references. —Write Box No. 11, c/o Hon. Secretary, 20, Lushington Road, Harlesden, N.W.10.

Member, at present Works Manager of firm of motor manufacturers, with long experience in organising, desires change. Wide connection with Export Houses and Home Trade, and capable of handling sales. Particulars of past experience and references will be forwarded to any interested party.—Write Box No. 12, c/o Hon. Secretary

ELECTRICAL GAUGING DEVICES.

MECHANICAL engineers seem to be suspicious of any tool equipment which invokes the aid of electrical contact devices for gauging or size control, yet there is no doubt that a vast field remains to be explored in this direction. It is, of course, appreciated that expert tool designers, if they have expended the necessary time and labour to become proficient in their own profession, have little time for studying electrical science; but, in view of the fact that the principles involved in such devices as exist are comparatively simple, it is worth while to keep in mind the possibility of invoking the aid of electricity to solve unusual gauging problems.

Leaving out of consideration the question of individual motor drives for machine tools and the electrical equipment associated therewith, the majority of electrical apparatus which is at present used in machine shops and inspection departments may be roughly divided into two classes. These include, first of all, gauging devices pure and simple for testing finished components, and, secondly, sizing indicators and control mechanisms which are employed during the processes of machining or grinding. The second class is the more widely known, but a few examples of both types of equipment may serve to indicate the possibilities of electrical apparatus.

Sizing Indicators.

The majority of readers will be familiar with sizing indicators of the type used on cylindrical grinding machines, either for indicating when the work has reached the finished size or for controlling the machine automatically by means of relays which close an auxiliary circuit, by means of which the feed is operated. The wheel control caliper employed on the Blanchard surface grinding machine also comes under this category. It takes the form of a shoe which makes contact with the work as it leaves the grinding wheel, so that as long as the parts fall within the prescribed limits the control circuit remains open. When, however, owing to wheel wear, the work reaches the upper limit of thickness, the increased friction on the shoe is sufficient to move it from the normal position, which has the effect of closing a switch, and the feed mechanism is momentarily engaged to feed the wheel towards the work by a small amount.

An equally interesting method of size control consists in maintaining the cutting face of the grinding wheel in a given plane by working from the face of the wheel itself, and not from the work. This principle is utilised, for instance, on the Maag gear grinder, where a diamond is periodically advanced until it makes contact with the face of the wheel. If the wheel face is in the

correct plane no movement takes place, but if worn down appreciably the additional movement of the diamond brings into action a compensating device which operates until the wheel face is brought back to the normal position.

In connection with devices which are used on machine tools, it may be mentioned in passing that quite simple electrical indicators can frequently be rigged up by the tool-room by making use of lamps which are included in an electrical circuit, so that they light up and give an unmistakable indication when the correct size is reached. Such apparatus proves extremely useful on deep boring or grinding operations, where the possibility of scrap is accentuated by the difficulty of gauging by the usual methods.

Gauging Equipment.

With regard to the use of electrical devices for gauging in the inspection department, it is surprising how few of these are to be found except in the most modern factories. Provided, however, that light contacts are not made to carry a heavy current, electrical gauging equipment can be made quite as reliable as the mechanical or optical types. Moreover, the difficulty which would arise if a heavy current were passed through the gauging elements can easily be overcome by employing a sensitive relay which will operate with the most minute current to close a heavier circuit which can be made to carry any current required.

As an example of this type of equipment, a simple form of gauge used by the Ford Motor Co. for testing the closing pressure of piston rings may be mentioned. The gauge consists essentially of a slot through which the ring is passed edgewise, so that it makes contact on one side with a fixed anvil, and on the other side with a movable gauging element operating against spring pressure. The movable element is made to control an electrical circuit by means of which one or more lamps are lighted according to the pressure required to close the ring.

Another interesting electrical gauging device is employed by a large firm manufacturing type-casting machines, for measuring from the bottom of the impression in a type matrix. Owing to the fact that the matrices cover a wide range of characters, whilst the measurement must be made from the lowest point in the impression, which is formed at the bottom of a conical hole, gauging by any of the usual methods is next to impossible. A floating needle, which finds its own position in the impression, is therefore used in conjunction with an electrical circuit, which indicates when the lowest point in the impression has been brought to the correct plane. A cutter mounted on a fixed slide is then brought into action to mill off the excess metal from the top of the matrix. Thus the type when cast is of a uniform height measuring to the type face or printing surface.